

Simulating the Adoption of Energy Efficient Technologies

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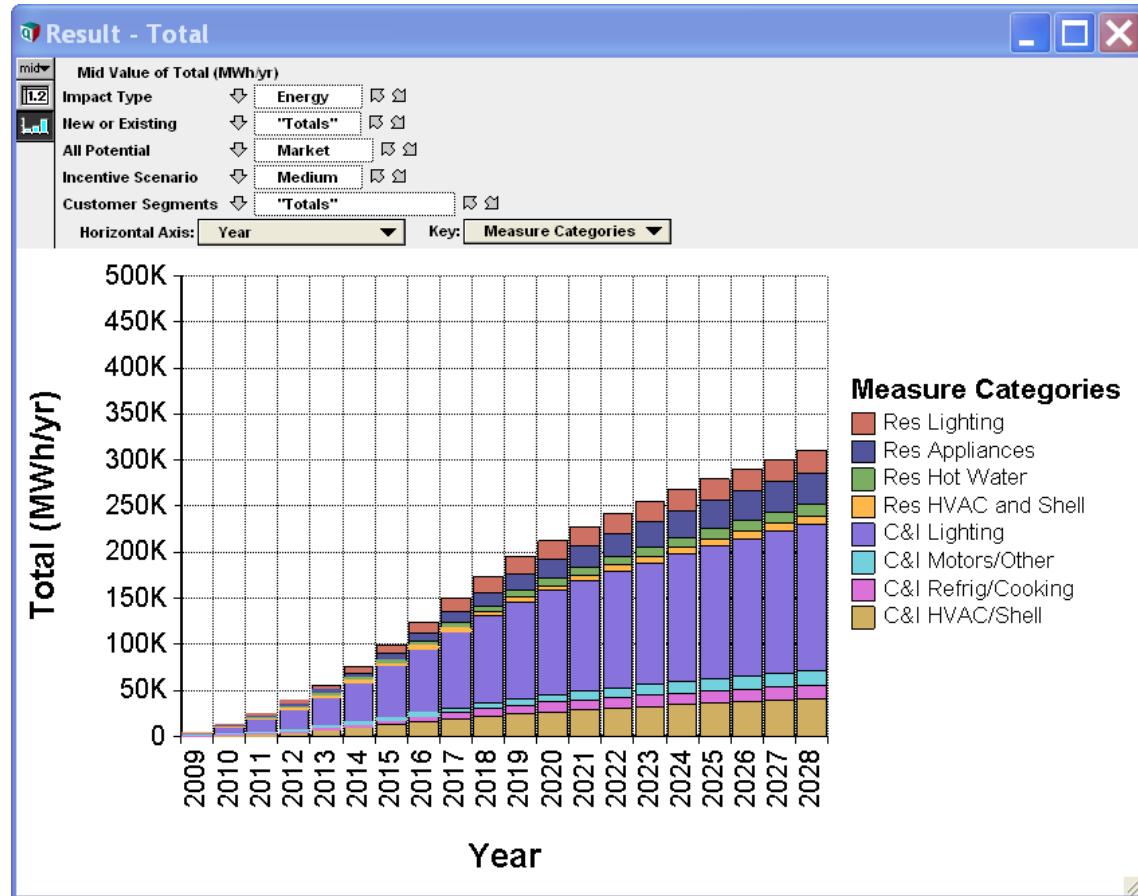
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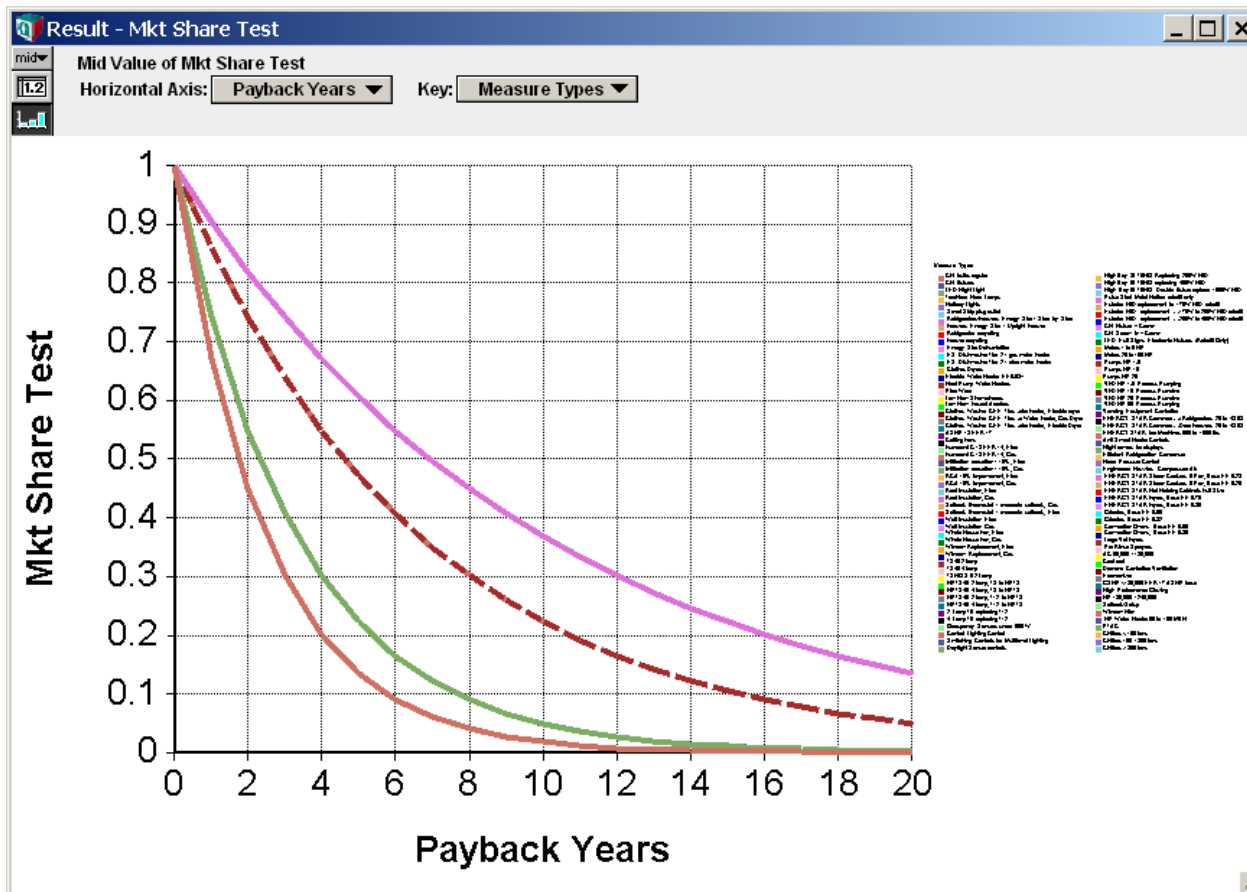


DSMSim™ is a DSM potential model and program planning tool that simulates EE technology adoption under various planning assumptions.

- Bottom-up (from measure level)
- Tracks each technology stock's "churn"
- Calculates EE technology market share for replacement as a function of payback time
- Simulates adoption using advanced technology diffusion theory (enhanced Bass diffusion model)
- Algorithm varies for replace-on-burnout, retrofit, and brand new technologies



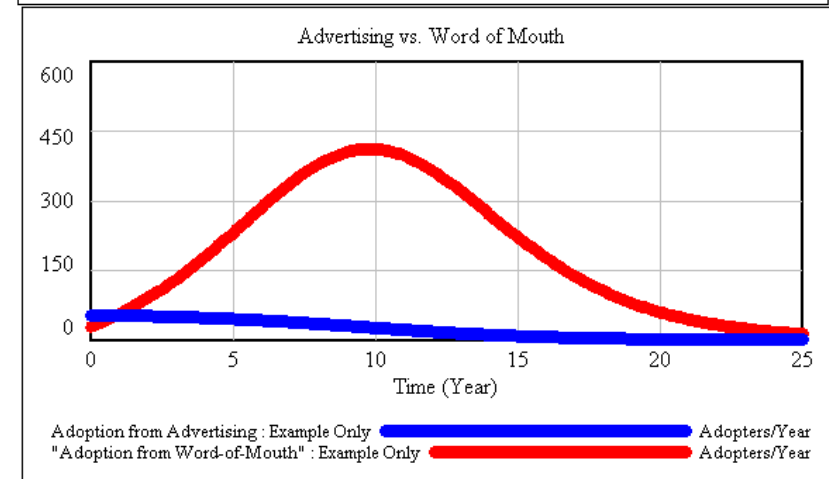
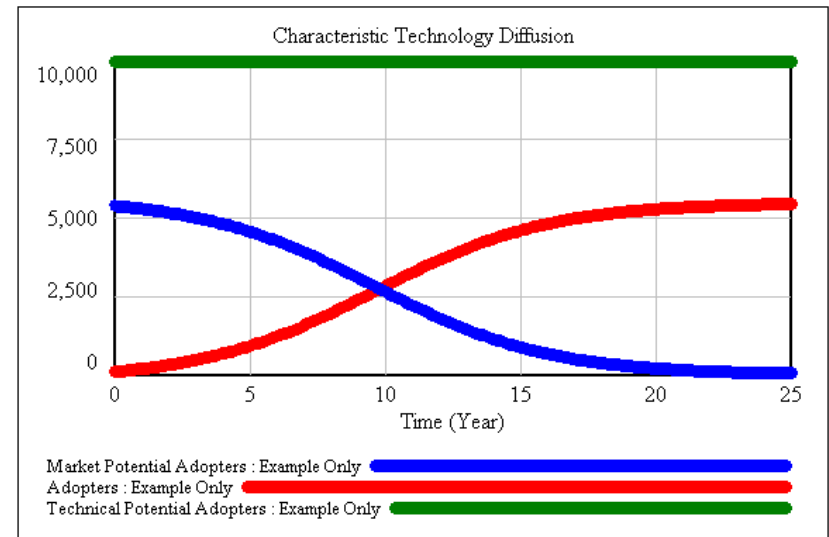
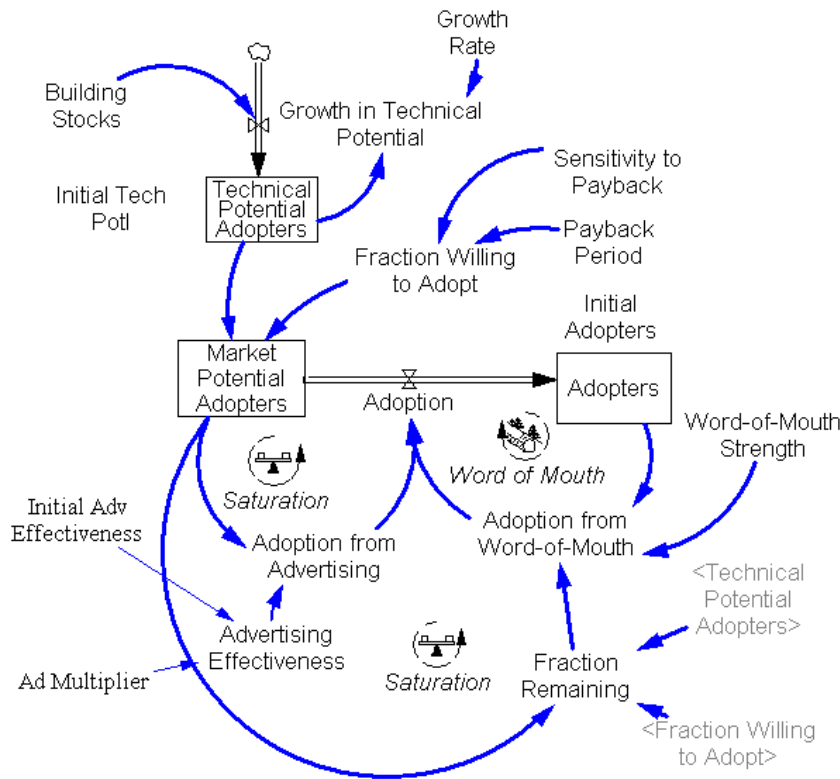
“Equilibrium” market share is estimated as a function of payback.



For illustration only.

Simulating Technology Diffusion: Bass Diffusion Theory^{1,2}

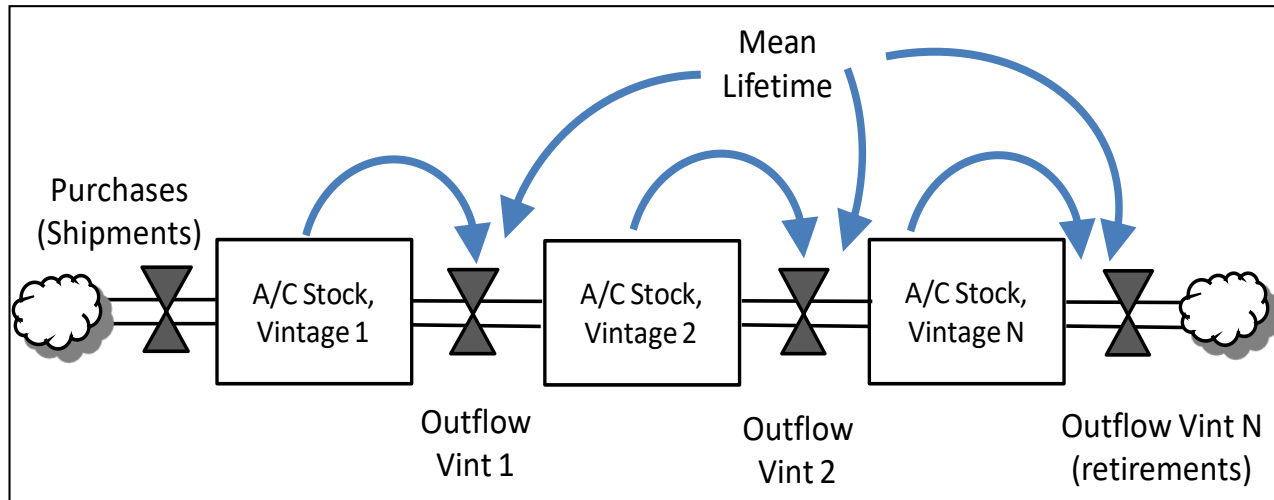
Approach to equilibrium is simulated using diffusion theory: adoption/awareness from external sources (e.g., marketing campaigns) as well as word-of-mouth are explicitly simulated.



1. Bass, Frank (1969). "A new product growth model for consumer durables". *Management Science* 15 (5): p215–227.
2. Also see Sterman, John D. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin McGraw-Hill. 2000. p. 332.

Simulating technology stock turnover

Technology stocks are simulated using an aging chain¹, which accurately characterizes the shape of technology retirements.²



Example shown here is for air conditioning (A/C) units, but the approach is universal.

Purchases [AC Units/Year]: this is the inflow into the aging chain and was estimated using AC unit shipment data

AC Stock, Vintage n [AC Units]: $= \int (Inflow_n - Outflow_n) dt$, where

Inflow, Vintage n [AC Units/Year]: = IF $n = 1$ THEN *Purchases*, ELSE *Outflow, Vintage $n-1$*

Outflow, Vintage n [AC Units/Year]: = *AC Stock, Vintage n* / (Mean Lifetime/ N)

N = Number of stocks in the aging chain (equivalent to the Erlang "shape factor")

dt = the time step for the numerical integration, in this case 0.25 years

1. Sterman, John D. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin McGraw-Hill. 2000. p. 470
2. Welch, C. and Rogers, B. "Estimating the Remaining Useful Life of Residential Appliances." ACEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, August 2010.

Technology performance & costs, saturations, customer behavior, and other data are considered in the simulation.

Key Input

- EE Measure Costs, Energy/Demand Savings
- Utility Data
 - Electricity Rates, Avoided Costs, Incentives (can also be an output), Energy Sales, Demand, etc.
- Initial Measure Saturation
- Maximum Measure “Density” (e.g., units/home)
- NTG Ratios
- Consumer Sensitivity to Payback
- Diffusion Parameters

Outputs required for estimating potential, B/C ratios, and other information useful to program planners/regulators are calculated.

Key Output

- Energy/Demand Svgs (Tech/Econ/Achievable)
- Utility Costs (Incremental and Cumulative)
- Portfolio & Measure B/C Ratios
- Incentive Levels
- Average \$/kWh
- Costs/Savings and % of Revenue & Elec. Sales

Input, output and structure are easily accessible via a graphical user interface.

Key Inputs

DSMSim™

Demand Side Management Simulator



Input

Measure Input	Edit Tabl	C & I	
Residential		Lighting	SubTabl
Lighting	SubTabl	Motors/Other	SubTabl
Appliances	SubTabl	Refrig/Cooking	SubTabl
Hot Water	SubTabl	HVAC/Shell	SubTabl
HVAC/Shell	SubTabl		

Other Input

Measures & Customer Segments	Utility Forecasts	Incentives	Diffusion & Market Share Parameters
Avoided Costs & B/C Testing	Dynamic Simulation Parameters	Additional Technology Input	Misc.

Output

Model Details **More Output**

Potential	Calc mid	C & I	
Residential		Lighting	Calc mid
Lighting	Result mid	Motors/Other	Calc mid
Appliances	Calc mid	Refrig/Cooking	Calc mid
Hot Water	Calc mid	HVAC/Shell	Calc mid
HVAC/Shell	Calc mid		
<hr/>			
Potential as % of Sales	Calc mid	Calc mid	
Total		(MWh/yr)	Calc mid

Other Output

Annual or Incremental Savings		Incremental ▼
Incentive Scenario	Initialize	All ▼
Cumulative Utility Costs	(\$)	Calc mid
Cost, Svgs as % of Rev, Sales (%)	Calc mid	Calc mid
Ratio Cost % to Svgs %		Calc mid
Incr cost per 1st year kWh (\$/kWh)	Calc mid	Calc mid
Average \$/kWh	(\$/kWh)	Calc mid
Include in Portfolio		Result mid
Benefit to Cost Ratios	Utility Cost Test ▼	Calc mid

Inner Workings

Key Outputs

Example input table for C&I lighting measures (for illustration only)

Edit Table - C&I Lighting

Edit Table of C&I Lighting

New or Existing: Existing

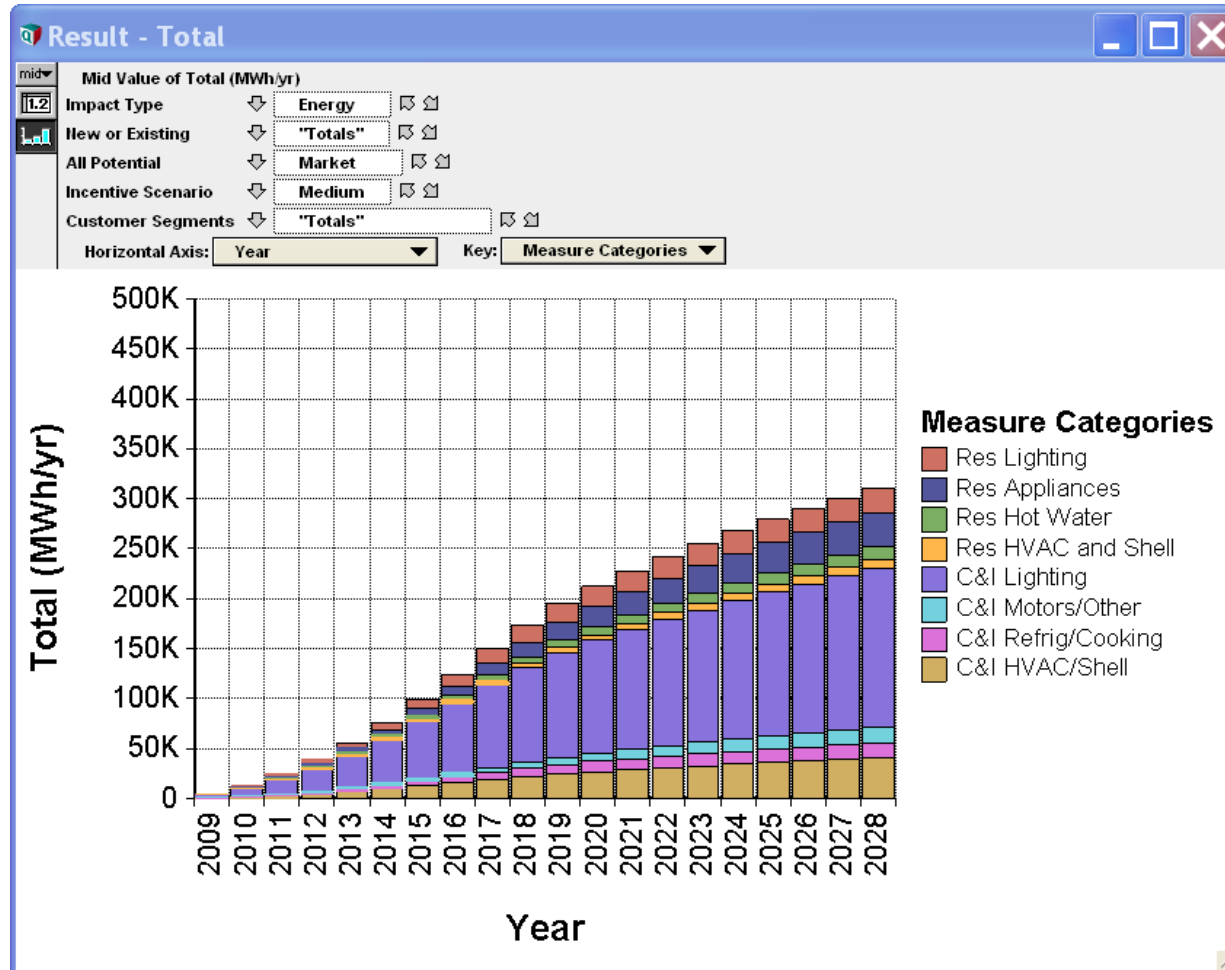
C&I Segments: Small Industrial

Comm Ltg Meas

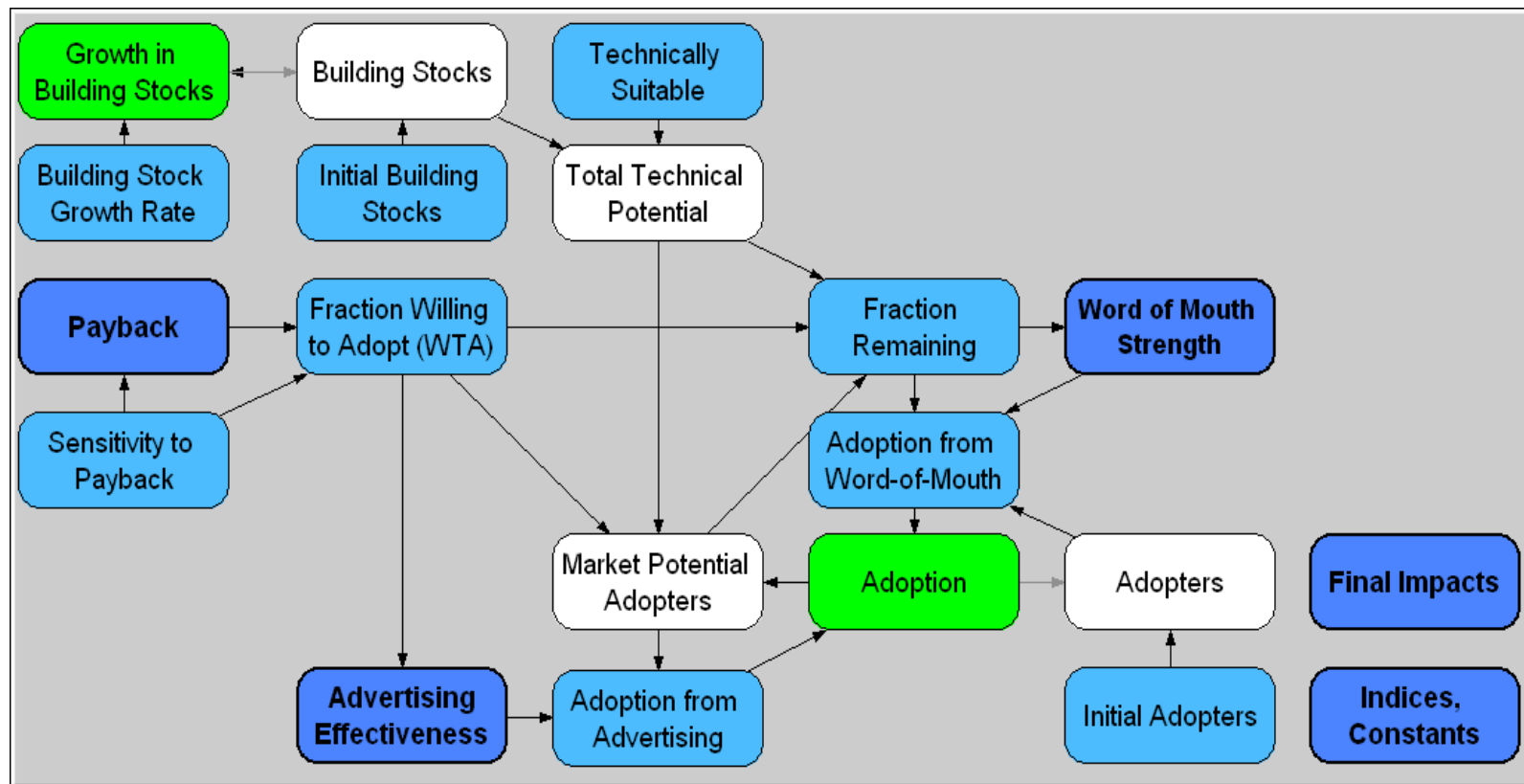
Params

	Energy Impact (kWh/Unit)	Peak Impact (W/Unit)	Measure Life	Technology Cost (\$/unit)
T8 4ft 2 lamp	69.90	19.00	12.00	41.00
T8 4ft 4 lamp	139.84	38.00	12.00	66.00
T8 HO 8 ft 2 Lamp	184.00	50.00	12.00	72.00
HPT8 4ft 2 lamp, T8 to HPT8	31.00	8.00	12.00	41.00
HPT8 4ft 4 lamp, T8 to HPT8	52.00	14.00	12.00	66.00
HPT8 4ft 2 lamp, T12 to HPT8	82.02	22.29	12.00	41.00
HPT8 4ft 4 lamp, T12 to HPT8	169.65	46.10	12.00	66.00
2 Lamp T5 replacing T12	44.16	12.00	12.00	107.00
4 Lamp T5 replacing T12	88.32	24.00	12.00	124.00
Occupancy Sensors under 500 W	397.00	110.00	10.00	144.00
Central Lighting Control	11500.00	3120.00	12.00	3700.00
Switching Controls for Multilevel Lighting	8000.00	2440.00	12.00	4000.00
Daylight Sensor controls	14800.00	4020.00	12.00	4000.00
High Bay 3L T5HO Replacing 250W HID	449.00	108.00	12.00	180.00
High Bay 6L T5HO replacing 400W HID	374.00	90.00	12.00	350.00
High Bay 6L T5HO Double fixture replace 1000W HID	1456.00	350.00	12.00	700.00
Pulse Start Metal Halide retrofit only	430.00	120.00	7.00	248.00
Exterior HID replacement to 175W HID retrofit	268.00	70.00	12.00	532.00
Exterior HID replacement above 175W to 250W HID retrofit	409.00	107.00	12.00	665.00
Exterior HID replacement above 250W to 400W HID retrofit	706.00	184.00	12.00	1064.00
CFL Fixture -- Comm	342.00	93.00	12.00	45.00
CFL Screw in -- Comm	166.00	45.00	2.00	3.00
LED Exit Signs Electronic Fixtures (Retrofit Only)	158.00	18.00	15.00	60.00

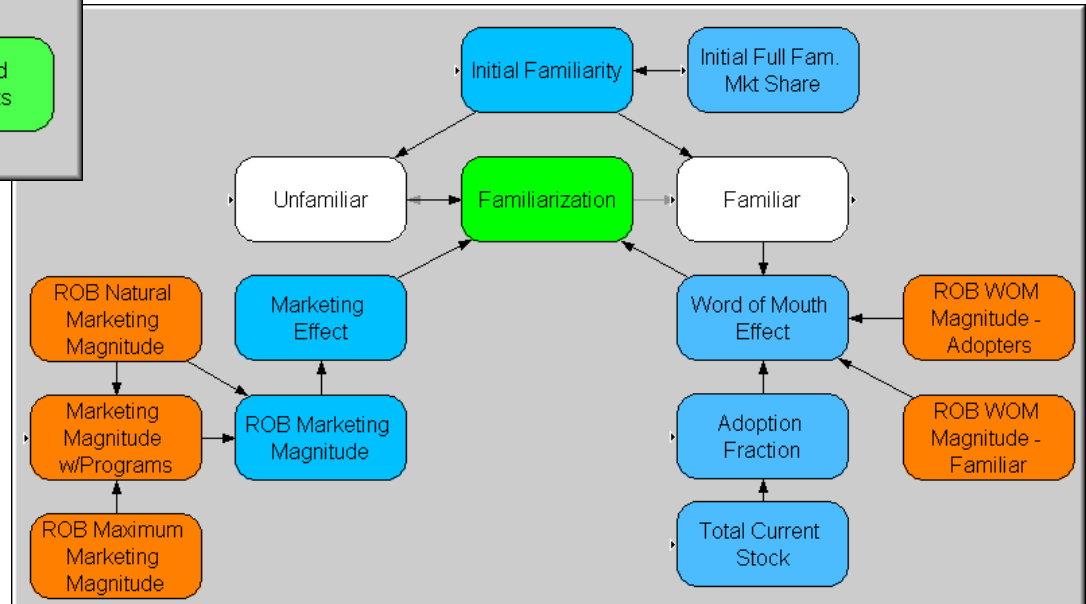
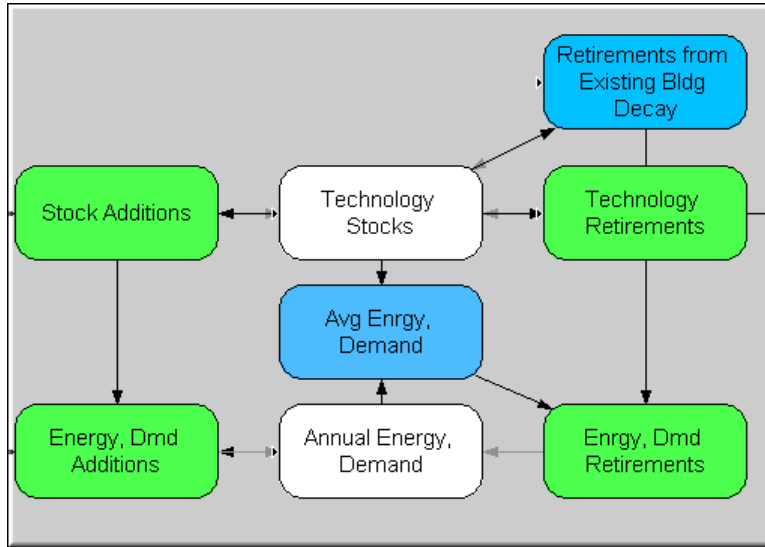
Example output aggregated by measure category



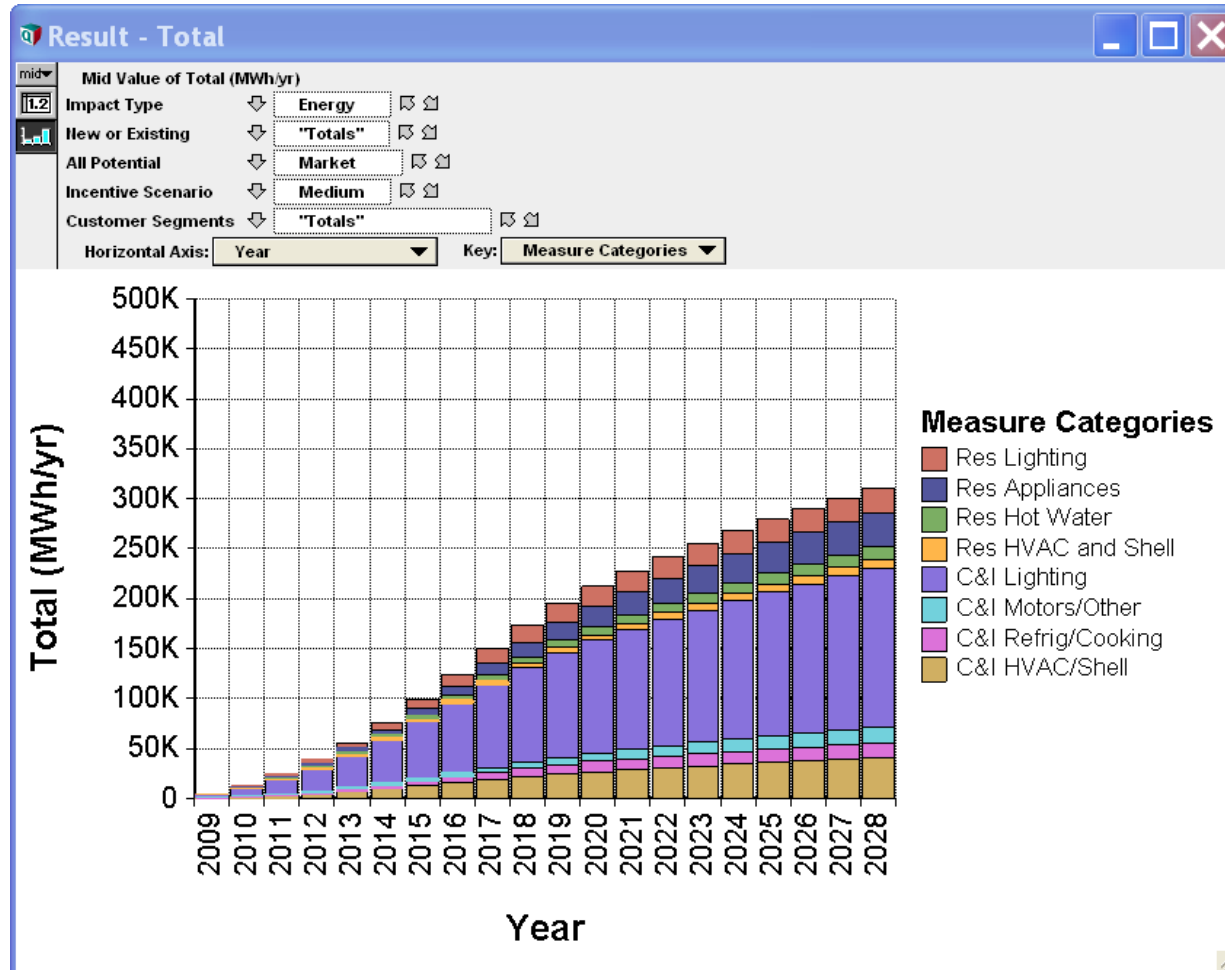
Example of graphical access to model structure



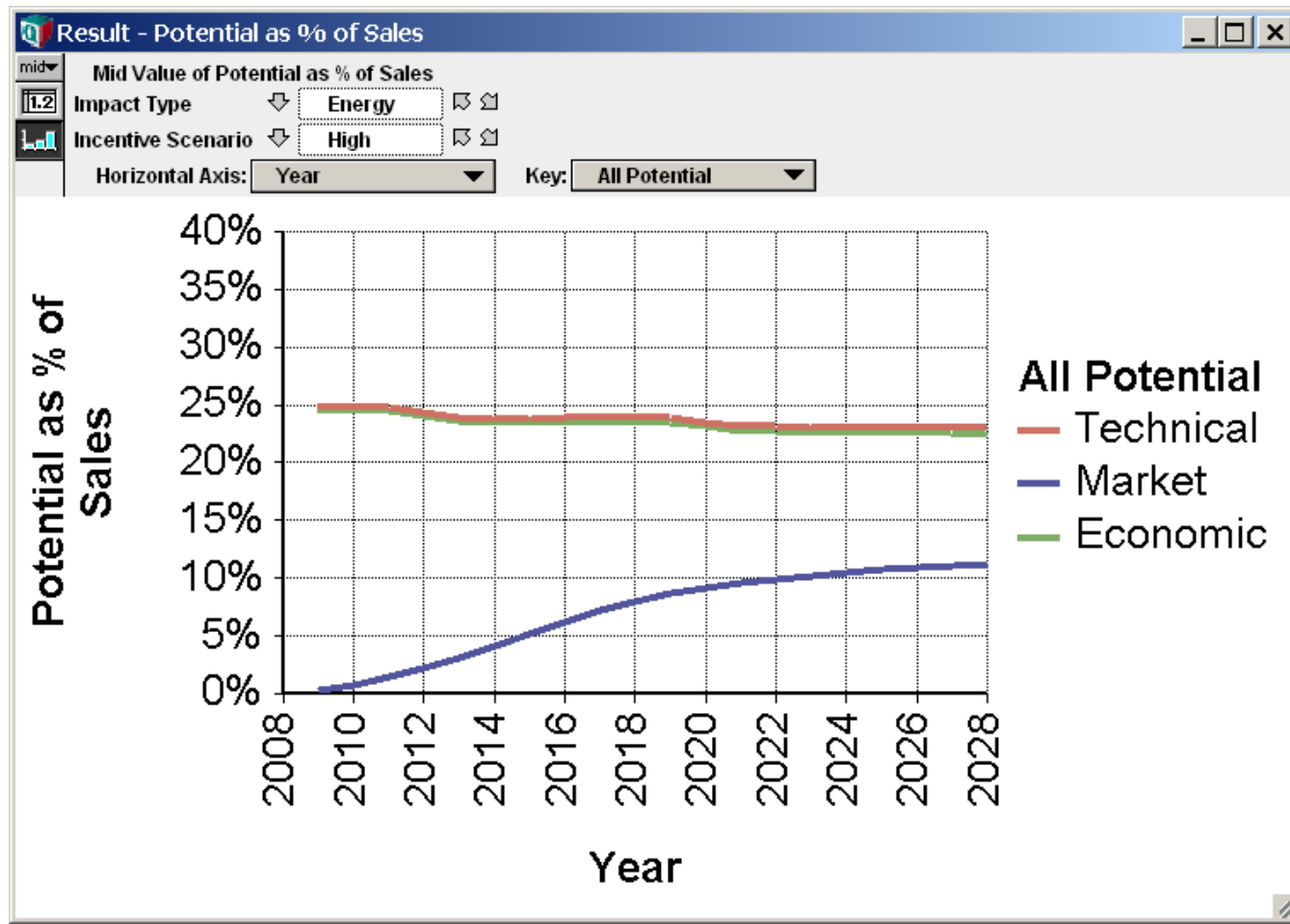
More model structure examples



Example output aggregated by measure category

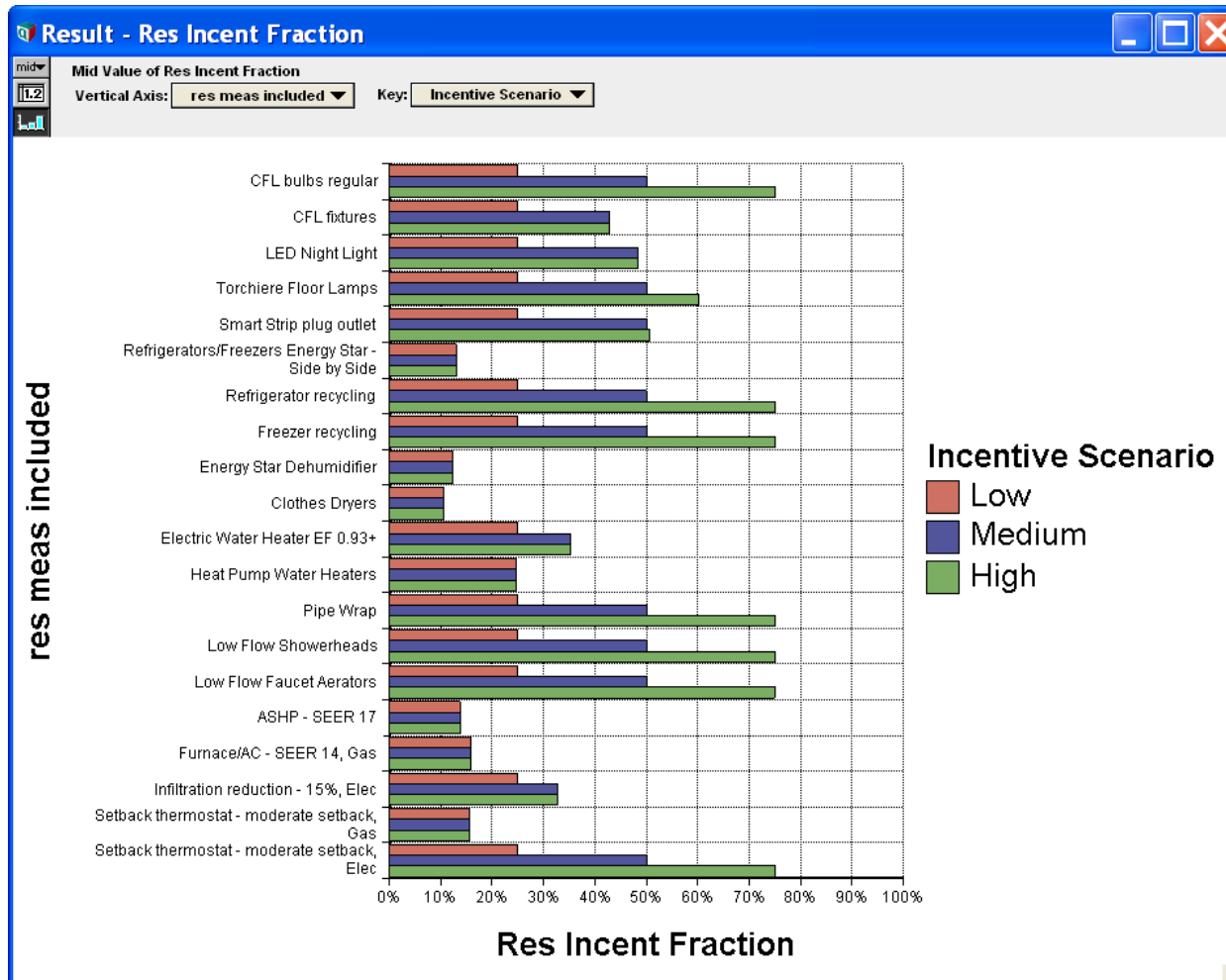


Example output of potential energy savings as a % of sales



(Demand Side Management Simulation) Model

Desired incentive levels by scenario are input and then constrained via calculation to ensure cost effectiveness at the measure level.



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